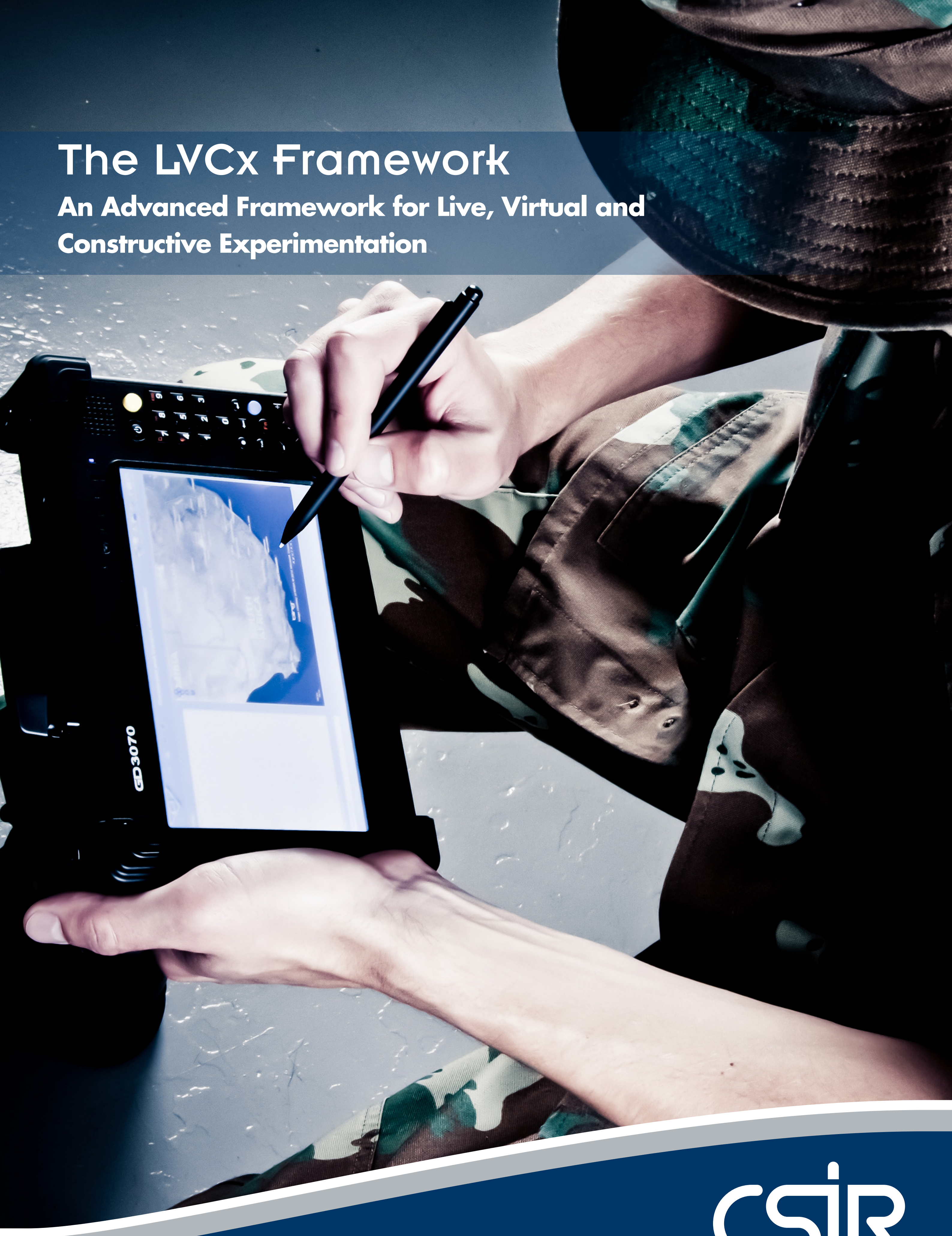
The LVCx Framework

An Advanced Framework for Live, Virtual and Constructive Experimentation



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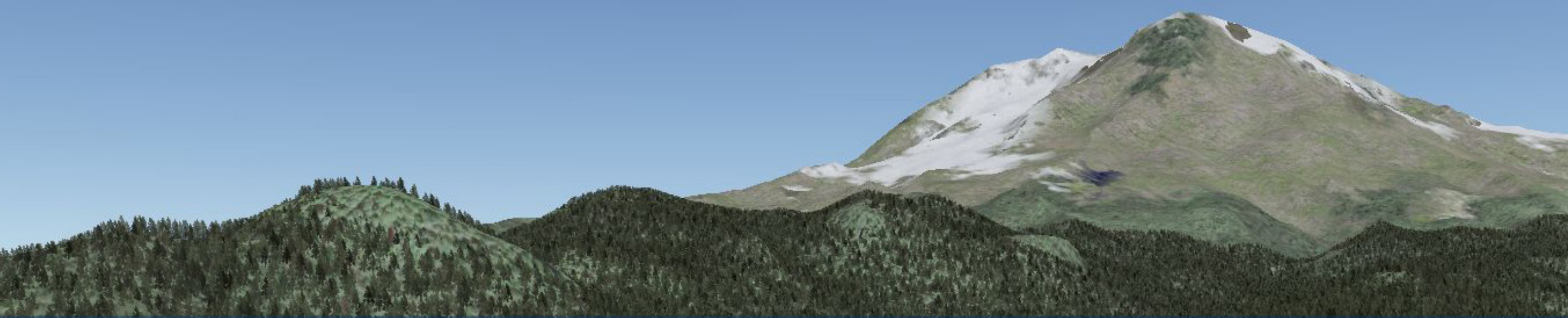

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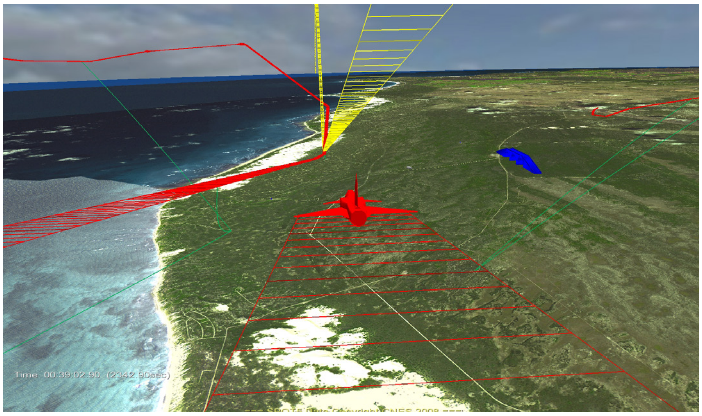
An Advanced Framework for Live, Virtual and Constructive Experimentation

The CSIR has a proud track record spanning more than ten years in supporting the South African Ground Based Air Defence System (GBADS) programme through simulation-based decision support and concurrent tactical doctrine development support.

This support is enabled by an advanced Live, Virtual and Constructive (LVC) C++ application development framework – originally referred to as the Virtual GBADS Demonstrator (VGD).

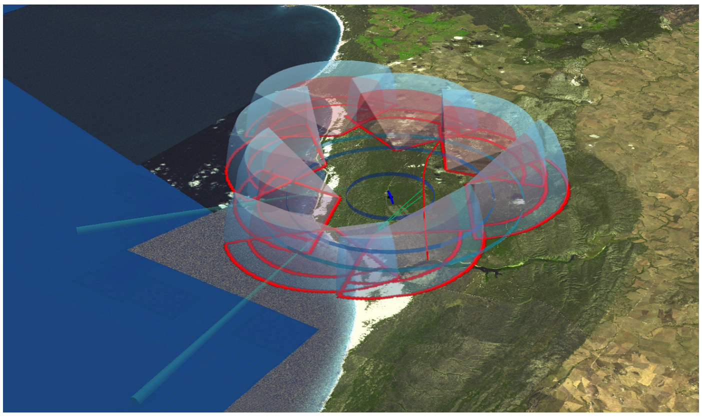


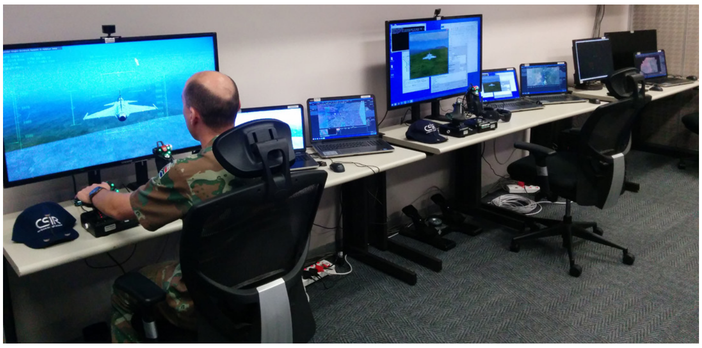
The framework enables:

- High performance modelling and simulation
- Integration of simulators and systems
- Interoperability of live systems
- 3D visualisation
- Middleware development

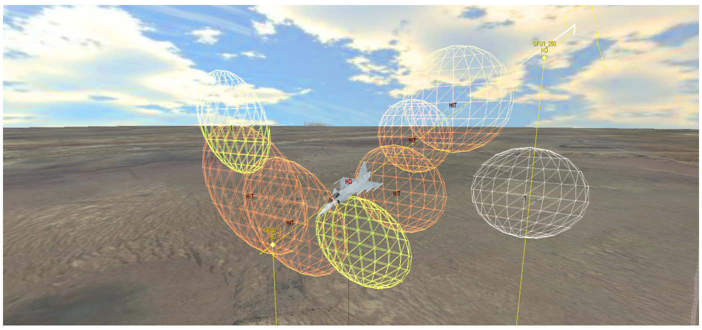
The framework is used for:

- Live, virtual and constructive experimentation
- System concept and trade-off studies
- System performance analysis
- System-of-systems behaviour analysis
- Acquisition and doctrine development support
- User requirements specification support
- Interoperability development support





The framework is developed by the CSIR and funded by the Department of Defence via ARMSCOR.

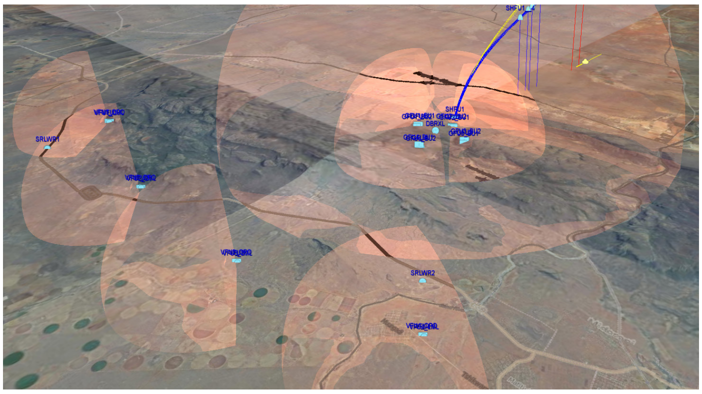


The LVCx Framework

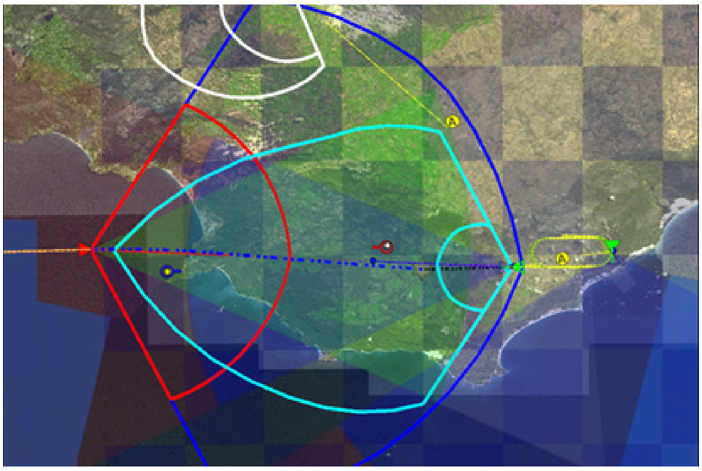
Simulate the Battlefield

The framework has its roots in modelling and simulation and includes the following:

- Platform modelling
- Sensor and weapon modelling
- System and operator modelling
- Data link and communications modelling
- Terrain analysis (line-of-sight)



The framework is ideal for developing large-scale many-on-many engagement simulations, using parameterised models.

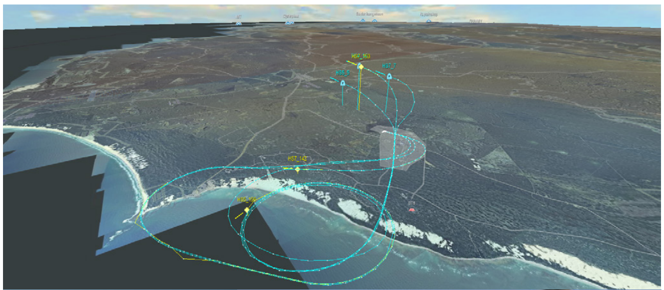


The framework supports real-time and as ast as possible execution with full support for Monte-Carlo analysis.

Integrate Systems and Simulations

A key feature of the framework is its integration capabilities. The framework supports:

- Integration of live systems and simulators
- Sensor track fusion
- Bridging independent networks (range extension), with options for encryption and compression on backbone links



The framework includes integration with:

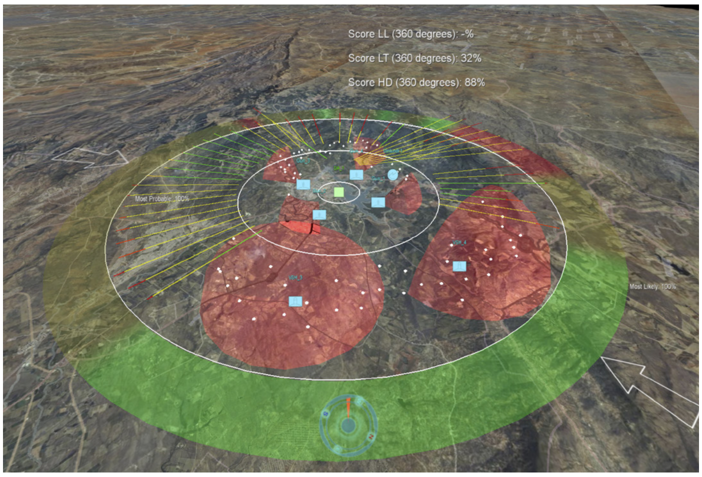
- LinkZA platforms
- Operational Air Force, Military and Navy Command and Control systems
- Military radar systems
- CSIR experimental systems
- Blue Force Tracking systems (incl. Spidertracks)
- ADS-B and AIS systems (incl. RTL-SDR receivers)
- Google Earth
- FlightGear
- Military unmanned aerial systems
- Cmore

Framework objects communicate using a common data model (data-centric architecture), which ensures a linear level of effort with new modelling and integration developments.

The LVCx Framework

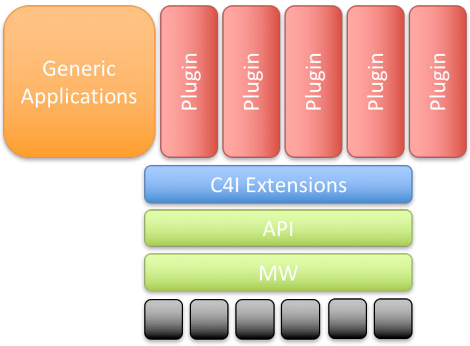
Build Applications and Tools

The framework has a layered architecture that scales as required. It is already integrated with Sentience3D (a two or three dimensional GIS viewer based on Open Scene Graph) and Qt (a user application development toolkit).



The framework provides the required building blocks to quickly develop two or three dimensional operator consoles and tools.

The framework includes reusable C++ libraries for networking, math, coordinate transformations, XML parsing, Terrain elevation data loading, line-of-sight, high-performance clocks, date and time handling, random number generation and string handling. All libraries are available across all supported platforms.



The framework is extended using plugins that provide dynamic additions to the framework and allow users to focus on what is important to them. Plugins also enable integration with third party components not created with C++.

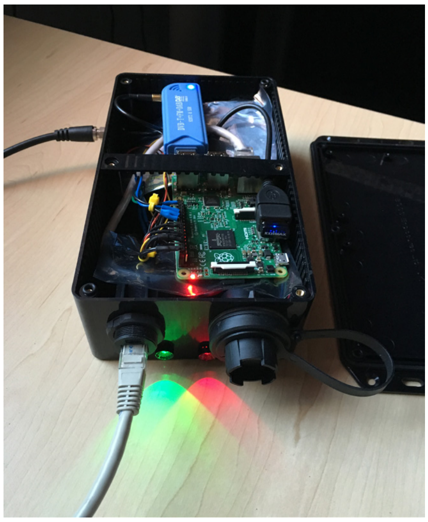
Built-in automated testing ensures updates and additions do not interfere with existing functionality. The test system tests can cover anything from the functions of individual components to the behaviour of full simulation scenarios.

With its layered data-centric architecture, the framework can easily be extended to support vendor standards such as the High Level Architecture (HLA) for simulation interoperability.

Deploy Everywhere

At the framework core there is a high-performance publish-subscribe style middleware. It supports distributed, as well as multi-threaded object execution. The multi-threaded object execution ensures good utilisation of local host resources, while the distribution allows an application to scale to multiple hosts on a network.

The core simulation and interoperability features can run on embedded, low power and headless platforms – it supports Windows, Linux and OSx. Alternatively it can be employed as a set of services to the back end of other applications.

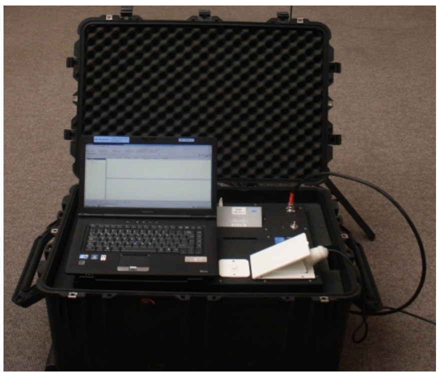


Applications created with the framework have direct access to any special purpose hardware that may exist on an embedded platform.

The framework is ideal to develop deployable systems, such as:

- Smart sensors
- Unmanaged communications gateways
- Protocol adaptors and bridges

The framework utilises the latest C++11/14 features to optimise portability and minimise dependencies.



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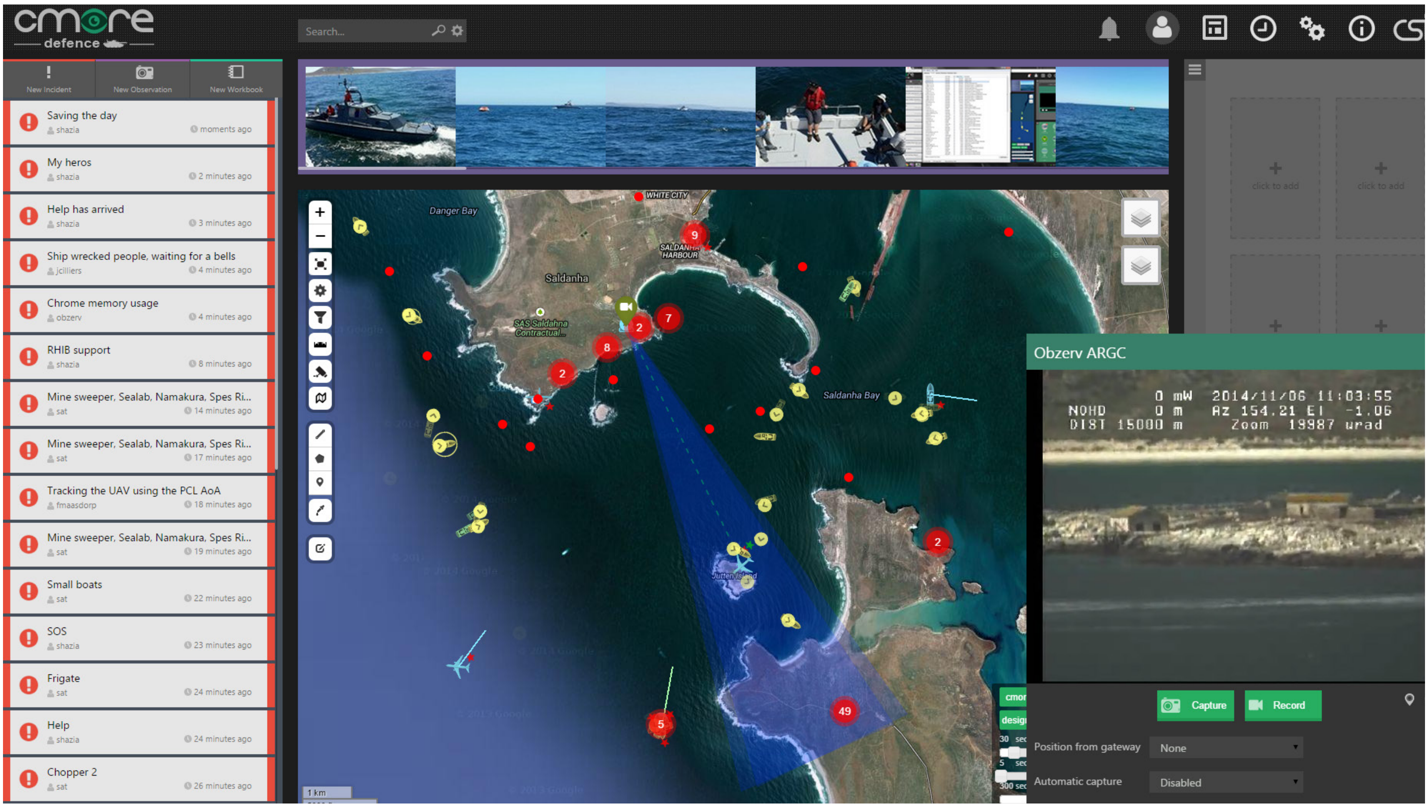

Experiment Anywhere

The framework provides a truly unique blend of simulation and system interoperability. It enables an all-in-one environment with the following capabilities:

- Operator-in-the-loop simulation
- Hardware-in-the-loop simulation
- Running virtual systems in live field trials
- Multi-sensor track fusion
- Interoperability

The framework runs on a virtual time-base and any execution, even with live data in the field, may be paused for analysis and training purposes. The time base can then be sped up again to consume any buffered data.

The interoperability gateway, used by the CSIR's Interoperability Development Environment (IDE), has been developed with the framework. The first versions of the gateway started integrating systems in South African National Defence Force (SANDF) field experiments in 2008.

The IDE gateway can be deployed on embedded devices to create smart sensors. It is permanently deployed as part of the Cmore system, providing continuous sensor information.

The IDE gateway is used in live SANDF and the South African Police Service experiments and field exercises, with collaboration across CSIR research areas. It is at the heart of the CSIR concept development, experimentation and simulation process, used to assist the SANDF in rapidly testing new technology solutions for border safeguarding.

The LVCx Framework

Current Applications

Current applications built with the framework include the following:

- **Ground Based Air Defence Simulator:** High to medium fidelity modelling of weapons, sensors, systems, automated tactics and threats within the local GBADS domain. The simulator is used to support acquisition, concurrent doctrine development and user requirements specification. It is designed for the system-of-systems analysis of timelines, performance and saturation of the air defences.
- **35mm Anti-Aircraft Autonomous Gun Model:** Extension to GBADS modelling with increased fidelity of the 35mm Anti-Air Gun system.
- **Mission Control Concept Evaluation Centre:** Low fidelity simulation of aircraft and mission control tactics (with integration of the South African Air Force mission control terminals). The purpose of this system is to help the user develop a requirement specification for Air Force system upgrades.
- **Fighter Mission Simulation Framework:** Medium to high fidelity modelling of Gripen systems and tactics to do trade-off analysis and user requirements specification support. This includes platform survivability and weapon effectiveness against foreign GBADS.
- **Data Link Processor:** Tactical data link interoperability and integration of existing military platforms and systems. By supporting legacy and experimental system interoperability, it takes the IDE gateway concept further, with a strong focus on deploying it for the SANDF.
- **Gripen LinkZA C2 Ground Station:** The Gripen ground station is a concept demonstrator for a deployable command and control (C2) ground station. It implements the aircraft's LinkZA uplink, downlink and air link. As a C2 ground station, the operator can command the aircraft and receive situational awareness from the aircraft. As a Gripen node emulator, the ground station emulates an aircraft. For emulation purposes all required aircraft systems and message packing is realistically modelled – the ground station then appears as an air link member to any other aircraft in the air. The Gripen ground station has worked well and the concept has proven itself during trade shows, experiments, field trials and even bombing exercises.
- **Multi-Sensor Track Fusion Algorithm Test-Bed:** Medium to low fidelity modelling of sensor systems, a fixed interface for multi-sensor tracking algorithms and fusion performance analysis provides a low-cost multi-sensor information fusion and evaluation test-bed. Algorithms can be tested against different types of sensors, including communications delays and sensor alignment errors.
- **Low-Cost ADS-B and AIS Sensors:** Smart and deployable sensors running on embedded ARM single board computers with one or more Software Defined Radio (SDR) receivers. Automatic dependent surveillance – broadcast (ADS-B) is a Civilian cooperative air traffic tracking system. Automatic Identification System (AIS) is a maritime cooperative vessel tracking system. The ADS-B sensor is currently working well and continuously feeding data to Cmore.
- **Air-to-surface warfare concepts test-bed:** A simulation of a target rich area defended by foreign air defence systems is used to support acquisition, concurrent doctrine development and user requirements specification. It is designed to evaluate concepts for future target detection, location, identification and engagement.

The framework and its applications are used across the CSIR's Defence Peace Safety and Security unit.

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